SOME EFFECTS OF EXPERIMENTAL UNIT SIZE ON THE ACCURACY AND PRECISION OF COTTON GINNING RESEARCH DATA

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PREFACE

The work reported in this thesis was conducted in conjunction with a cooperative cotton ginning research project between the Oklahoma Agricultural Experiment Station and the U. S. Department of Agriculture. While this work was not one of the objectives of the project, the results reported herein should aid in the successful attainment of the project objectives through more effective research procedures. This investigation was made to obtain information on which to base the selection of seed cotton test lot size for cotton ginning experiments.

The author is grateful for the counsel and encouragement given during this study by Professor E. W. Schroeder, the thesis advisor.

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CHAPTER I

INTRODUCTION

In cotton ginning research as in other fields of agricultural research, an attempt is made to estimate the characteristics of a population of cotton by ginning small samples of that population. In a ginning experiment which is to be analyzed by statistical methods, the number of samples to be ginned is determined by the degrees of freedom desired for testing treatment differences. Usually, 24 to 30 samples are required to provide a minimum of 18 degrees of freedom. But how large should each of these samples or ginning test lots be in order that the data gained therefrom will reliably represent the population from which it was drawn?

In the past, 400-pound lots of harvested cotton have been used for ginning experiments when the experiment was conducted with full-sized gin machinery. As far as is known, this figure was chosen as a result of several years experience in ginning experimentation, but without statistical investigation of the minimum permissible lot size.

When 400-pound lots are used, the amount of cotton necessary for an experiment is approximately 10,000 pounds. Frequently, due to drouth or other reasons, cotton suitable for the experiment is not available in this amount; although some lesser amount might be available. In this event, should the experiment be conducted with lots smaller than 400 pounds, or should it be abandoned? When this situation has occurred in the past, the experiment has usually been conducted with a reduced lot size, but only with some doubt concerning the reliability of the results obtained therefrom.

If lots smaller than 400 pounds could be used for ginning experiments, investigations could often be conducted with an amount of test material previously thought to be inadequate and which therefore was not always utilized. Conversely, if a given amount of test material were available for a particular experiment, the use of smaller lots would permit additional replications with the accompanying possibility of detecting smaller significant treatment differences.

Many aspects of the procedure used in conducting a cotton ginning experiment could be scrutinized for statistical soundness. This study is limited to an examination of only one of those aspects, experimental unit size. It is directed specifically toward finding a method of reducing experimental unit size (lot size) without sacrificing the reliability of experimental results.

CHAPTER II

OBJECTIVE

The objective of this study was to investigate the effect of a reduction in experimental unit size on the accuracy and precision of estimating population parameters in cotton ginning experiments with full-sized gin machinery.

In this thesis, accuracy refers to the degree with which the estimated attribute mean coincides with the true mean of the population parameter under consideration. Precision refers to the variability of the observations which establish the estimated mean of an attribute.

In a ginning experiment, the researcher is interested not only in accurately estimating the mean of an attribute, but also in establishing that mean with sufficient precision that it will lie within a relatively small confidence interval. It is conceivable that one lot size would establish an attribute mean as accurately as a second size, but that the variability of observations from the former lot size would be so great that significant differences between ginning treatments could not be detected by the F test. Whereas the second lot size with less variable observations would permit the detection of significant treatment differences with means identical to those from the former lot size.

CHAPTER III

REVIEW OF LITERATURE

Agricultural research workers have made various attempts to devise statistical methods of determining the optimum size of experimental unit (plot size) from uniformity data. For example, McDonald (1) working with cotton, and many others working with various crops used the coefficient of variation as the criterion of optimum plot size and shape. It was the common experience of these investigators that the coefficient of variation decreased as plot size increased, but that economy of land use also decreased as plot size increased (2). The usual technique in establishing optimum plot size by such methods was to graph the coefficient of variation or standard deviation against plot size. The optimum plot size was considered to be just beyond that point on the curve where its rate of change was greatest (3). Smith (4) however, points out that the foregoing procedure is fallacious since the point of maximum curvature or greatest rate of change depends entirely on the scale of the co-ordinates against which the observations have been plotted. He suggested that a more realistic representation would be to plot the logarithm of plot size variance against the logarithm of plot size. He showed by this method that the reduction in variability between plot sizes was proportional to the increase in plot size; that is, there is an inverse linear relationship between the size of experimental unit or plot and the variability of observations.

Smith (4) then developed an empirical formula for estimating the most efficient size of plot for any given field experiment. This formula contains only one independent, unknown quantity, a coefficient of soil heterogeneity. In order to obtain a value of this coefficient for a particular field area, uniformity trials or "blank" experiments must ordinarily be conducted. By using plots of unit size in these uniformity trials and combining various numbers of plots in the analysis of variance to obtain the effect of different plot sizes, the plot size variance could be graphed on logarithmic co-ordinates against plot size as discussed earlier. The slope of the resulting linear curve then represented the coefficient of soil heterogeneity needed for determining optimum plot size.

Koch and Rigney (5) later proposed a technique for reclaiming information on soil heterogeneity from certain types of experiments which included differential treatments, such as variety. The technique was essentially one of reconstructing the analyses of variance from previously conducted split plot or incomplete block experiments in such a manner that they simulated uniformity data. The coefficient of soil heterogeneity could then be determined by the logarithmic graphing procedure suggested by Smith (4). Thus, optimum plot size could be determined without the necessity of conducting uniformity trials.

Investigations aimed at determining the effects of experimental unit size on cotton ginning data have all been with small, laboratory-sized gins. The principle reason for these investigations was to determine what seed cotton sample size should be ginned from each field plot in order to reliably establish lint percentages. Quimby and Stephens (6) ginned fifty samples each of 30 pounds, 10 pounds, and

200 grams. The 30-pound and 10-pound samples were ginned on a 20-saw gin; while the 200-gram samples were ginned on an 8-saw gin. It was found that the standard deviation in lint percentage as determined from the 10-pound samples was lower than those associated with 30-pound and 200-gram samples. Significant differences were also found among lint percentage means established by the different sample sizes. It was concluded that the use of any of the three combinations of sample size and gin size would give reliable lint percentages from which to compute acre lint yield; but that the use of the larger gin would result in a more accurate result.

Vantine (7) later conducted investigations similar to those of Quimby and Stephens (6). He ginned twenty 10-pound samples on a 20-saw gin, and fifty each of 200-gram and 50-gram samples on an 8-saw gin. It was found that the standard deviation of lint percentage increased as the sample size decreased. It was concluded that the differences in lint percentage means as established by the different sample sizes were so small in comparison to other experimental errors that correction for such differences was not warranted.

Johnson and Looney (8) expanded on the foregoing investigations by ginning six to eight different sizes of samples on 8, 10, and 20-saw gins as well as on two sizes of roller gins. From these investigations, recommendations were made for the minimum size of seed cotton lot to be used on each size and type of gin. In addition to determining the effect of sample size on lint percentage, it was noted that lint grade showed a tendency to decrease as sample size increased.

CHAPTER IV

METHODS AND PROCEDURE

A. Selection of Evaluation Technique

To utilize the method proposed by Smith (4) for determining optimum plot size, a coefficient of test material heterogeneity would need to be determined from a blank ginning experiment. While this could probably be accomplished, the coefficient would be applicable to the one finite quantity of test material from which it was determined, just as a coefficient of soil heterogeneity would apply only to a finite field area. Once the coefficient of soil heterogeneity is established, it is applicable to that area for a period of several years thereafter. However, it is doubtful if a coefficient of cotton heterogeneity would be applicable to more than one ginning experiment since the cotton for other experiments would be grown on other field areas, perhaps under different weather conditions, and might be of another variety and harvested by other methods. Even when a ginning experiment is repeated in succeeding years, the possibility of obtaining experimental material of similar variability for each year is extremely remote. Thus it appears that the proposals advanced for determining optimum field plot size are not applicable to this study.

The evaluation of experimental unit size studies with laboratory-sized gins was apparently a process of observing the pattern of standard deviations associated with the different lot sizes for the one attribute computed.

For this study it was decided that information could be obtained about the effects of experimental unit size on the accuracy and precision of establishing attribute means by conducting a ginning experiment wherein the only variate was lot size. The cotton used in the experiment would be assumed homogeneous. The data obtained for each attribute by the different-sized lots would be subjected to an analysis of variance and F test. The means of an attribute established by different-sized lots should have no reason to differ significantly except by virtue of lot size itself. If the F test showed that the various attribute means differed significantly between lot sizes, then lot size would be suspected of producing some effect on accuracy of estimation. If significant differences were not found, this would indicate that each lot size was estimating the same mean and there would then be no evidence that lot size affected accuracy.

It should be realized that the true mean of a population parameter cannot be determined without using the entire population as a sample; therefore there is no known method of detecting whether or not a mean estimated by small samples coincides with the true mean. However, if the means established by different lot sizes differed significantly, this would indicate that the lot sizes were not representing a common population; and therefore some inaccuracy of estimation could be attributed to at least one of the lot sizes.

To evaluate the effect of lot size on the precision of estimating population parameters, it was decided to compare the variance of observations for each attribute from each of the different lot sizes. This would be done using the data from the same experiment used to evaluate the effect of lot size on accuracy. The variances associated with each lot size could be subjected to the F test to determine the statistical probability of a larger variance associated with a particular lot size. If this probability of a larger variance exceeded the 50 percent level for a certain lot size, then observations from that size would be suspected of being more variable than observations from the size to which it was compared.

B. Selection of Experimental Lot Sizes

A preliminary investigation of an exploratory nature was conducted with 250, 300, 350, 400, and 450-pound lot sizes in the year preceding this study. The results of this investigation were somewhat inconclusive, probably because so many lot sizes were used that the degrees of freedom for testing differences and computing variances were inadequate. However, there were several instances in this investigation of significant differences between the means established from different lot sizes. No consistent relationship was found between lot size and variability of observations.

In order to gain more degrees of freedom with a limited amount of experimental material, it was decided to conduct this study with additional replications and only two sizes of ginning lots. It was also believed that the effects of lot size could be more readily detected if extreme sizes were compared. In a ginning experiment, each machine through which the test lot passes undergoes a period of priming and de-priming. With some minimum size of lot, these machines would be operating in either the priming or de-priming period with no intervening period representative of continuous ginning. The amount of test material necessary for these two boundary conditions (probably about 30 pounds) is independent of lot size, but comprises a greater portion of the lot as lot size decreases. The subsamples of test material withdrawn from each lot passing through a machine are taken during the period of equilibrium operation. This subsampling cannot usually be performed in less than one minute, and the entire lot passes through some machines in a period of only three minutes. If the lot size were too small, there would be a risk of withdrawing subsamples during the priming or de-priming period. It was believed that 250 pounds was the smallest lot for which this risk could be avoided; therefore, 250 pounds was considered to be the smallest lot size which would be suitable for ginning experiments even though some smaller size might be equally precise and accurate.

Thus as a result of the foregoing considerations, the smaller of the two lot sizes to be compared was chosen as 250 pounds. Four-hundred-pound lots were chosen as the larger size since there was no desire to increase lot size over that already being used, and since the preliminary investigation gave little indication that a larger lot size would be desirable.

C. Design of Experiment

Eight replications with duplicate runs of each of the two lot sizes were ginned in a randomized complete block design. This resulted in 16 samples of each lot size. In this study, a block constituted the period of time necessary to process in random order one replication with duplicate runs of the two lot sizes being compared. The experiment was blocked with respect to time in order to help eliminate the effects of variations in temperature, humidity, and personnel fatigue which might occur during the two days required to execute the experiment.

The eight replications of the two lot sizes provided 31 degrees of freedom on which to base an analysis of variance for each of the attributes studied. A skeleton analysis of variance is shown in table I.

TABLE I

SKELETON ANALYSIS OF VARIANCE

Source of Variation	Degrees of Freedom
Total	31
Replications	7
Lot Sizes	1
Rep. x Size	7
Sampling Error	16
Within Small Lots	8
Within Large Lots	8

Differences between lot size means were tested for significance by the 7 degrees of freedom and variances associated with replication and lot size interaction. Half widths of the 95 percent fiducial intervals were computed using the t value of 7 degrees of freedom and standard errors of the means derived from the interaction variances; e.g., half width of interval = $({}_7t_{.05})$(Rep. x Size mean square/16)$^{\frac{1}{2}}$.

The variances within lot sizes were compared to each other by dividing the larger of the two variances by the smaller in order to yield an F value greater than unity so that tabulated F values could be used as the criteria of significance. Standard deviations and coefficients of variation were computed for each attribute for each of the two lot sizes. These two computations were based on the variances within lot sizes.

D. Experimental Technique

The procedure used in conducting this study was identical to that used for an ordinary differential ginning experiment. The procedure was as follows:

1. Bring into the gin the approximate amount of seed cotton randomly preassigned to that lot.
2. Weigh and record the amount of cotton.
3. Withdraw from this lot of cotton three subsamples weighing approximately one pound each for fractionation, and three 6-ounce subsamples for moisture content determination.
4. Gin the remainder of the lot.
5. Withdraw three fractionation subsamples of the cotton after each machine through which it passed, and three moisture subsamples after certain machines.
6. Collect, weigh, and record the weight of trash removed from the lot by each machine through which it passed.
7. Separate the lint ginned from this lot from that of the succeeding lot by placing a piece of paper on top of the lint in the bale press.
8. Weigh and record the total weight of subsamples withdrawn

from the lot.

9. Repeat the foregoing procedure for each of the remaining 31 lots in the study.

10. Weigh and record the lint ginned from each lot, withdraw three 6-ounce subsamples for grade and staple determinations, and three 6-ounce subsamples for lint-waste determinations.

11. Have grade and staple determinations made in cotton classing office of Agricultural Marketing Service, U. S. Department of Agriculture.

12. Withdraw 20 grams of lint or 50 grams of seed cotton from appropriate moisture content determination subsample, process through moisture oven, weigh and record dry weight.

13. Withdraw 100 grams of lint from each 6-ounce lint-waste subsample, process through lint-waste-analyzer apparatus, weigh and record quantity of clean lint and foreign material obtained.

14. Withdraw 300 grams of material from each 1-pound fractionation subsample, separate foreign material from seed cotton by hand picking and pneumatic fractionator, weigh and record resulting quantities of foreign material.

15. Convert weights of moisture and foreign material to percent using appropriate 20, 50 or 300-gram base. Average the three percentages obtained from the three subsamples withdrawn from each ginning lot.

16. Compute for each subsample from each lot the per-pound-value of the ginned lint on the basis of grade, staple, and Commodity Credit Corporation loan schedule. Average the

three values thus obtained from each lot.

17. Convert quantitative observations (ginned lint weight and weights of trash removed from each lot by each gin machine) to bale unit[1] values.

Since both the original lot weights and total weights of material withdrawn from those lots were somewhat variable throughout the experiment, some means of eliminating these two sources of error from the experimental data was necessary. Also, the quantitative attribute means obtained from small lots could not be directly compared by the F test to those from large lots since the difference in magnitude alone could result in finding significant differences between lot sizes. In addition, quantitative attributes are more easily interpreted and reported when expressed in terms of bale unit values.

Since the weight of subsamples withdrawn from a lot did not contribute toward subsequent quantitative observations, the weight of these subsamples should be subtracted from the original lot weight. The resulting weight of material actually ginned was then divided into the bale unit weight to form a multiplier by which all original quantitative observations from this lot could be converted to a bale unit basis.

[1]A bale unit is defined as the nominal amount of harvested cotton necessary to produce 500-pounds of ginned lint. For hand-snapped cotton, 2000 pounds of harvested material as it is received at the gin is considered to be a bale unit; while 2400 pounds of stripper-harvested cotton is needed for a bale unit because of additional foreign matter in the harvested material. The actual amount of lint produced from these weights of harvested cotton may vary between 400 and 700 pounds.

Using gin turnout or lint weight as an example, this procedure was as follows:

$$\frac{\text{Wt. of lint from bale unit}}{\text{Wt. of bale unit}} = \frac{\text{Wt. of lint obtained from test lot}}{\text{Wt. of material actually ginned}}$$

Actual weight of test lot before any sampling:	398 pounds
Weight of material removed by subsampling:	12 pounds
Weight of lint obtained from test lot:	101 pounds
Weight of bale unit of hand-snapped cotton:	2000 pounds

Then: $\frac{\text{lint wt. per bale unit}}{2000} = \frac{101}{398-12}$,

$$\text{lint wt. per bale unit} = \frac{(101)(2000)}{398-12} = 523 \text{ pounds.}$$

The multiplier for all quantitative observations from this hypothetical 400-pound nominal lot was therefore $\frac{2000}{398-12} = 5.18$.

The foregoing operation, then, corrects quantitative observations for variations in original lot weight, variations in subsample weights, difference in magnitude between large and small lots for the F test, and expresses the quantitative attributes in the universal language of ginners, i.e., bale unit values.

18. Compute returns per bale unit from gin turnout and per-pound lint value.
19. Compute variance and analysis of variance using qualitative values obtained in steps 11, 15, and 16, and quantitative values from steps 17 and 18.

With the foregoing procedure, the data subjected to statistical analysis for qualitative attributes were the average of three subsample observations; whereas, the data analyzed for quantitative attributes represented only one observation from each lot.

E. Specific Test Conditions

The facilities of the cotton ginning laboratory of the Oklahoma Cotton Research Station were used in carrying out this study. This included a 52-inch air-line cleaner; 14-foot burr machine; 52-inch, 7-cylinder, inclined screen cleaner; 60-inch, unit extractor-cleaner-feeder; 80-saw gin stand; and unit, saw-type lint cleaner. Apparatus used in the analysis of subsamples included a pneumatic fractionator, electric moisture oven, Shirley Lint Waste Analyzer, and miscellaneous weighing scales.

Each ginning test lot was processed through the gin machinery in the sequence delineated above. The rate of processing was four bale units per hour through the overhead cleaning machinery, and one bale unit per hour through the extractor-cleaner-feeder, gin stand, and lint cleaner.

The cotton used for this study was Stoneville 62 grown on dryland near Stillwater, Oklahoma, and harvested by hand snapping in the early portion of the harvest season of 1957.

CHAPTER V

PRESENTATION OF DATA

The various attribute means established by each lot size, the F values for testing differences between lot size means, the half width of the 95 percent fiducial intervals of these means[2], and the probability of differences between lot size means are presented in table II. Summarized in table III are lot size variances, the F values for testing differences between lot size variances, standard deviations, coefficients of variation, and the probability of differences between the variances of the two lot sizes. The probability levels in these two tables may also be thought of as the significance of the F values computed for evaluating accuracy and precision.

Table IV (in Chapter VI) lists the lot size selected for each of the 22 attributes as a result of consideration of the information presented in tables II and III.

Items 1 and 12-18 in these three tables are quantitative attributes while items 3-11, and 19-22 are qualitative attributes. Item 2, Returns, contains both quantitative and qualitative measurements since it was computed from Gin Turnout, lint grade, Staple Length, and Value of Lint. Abbreviations used in tables II, III, and IV are as follows:

ALC: Air-Line Cleaner

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[2]Fiducial intervals were computed at the 95 percent level since most ginning experiments are evaluated at that level.

BM: Burr Machine

7C: 7-Cylinder Inclined Cleaner

FDR: Extractor-Cleaner-Feeder

HLF: Gin Stand Huller Front

GS: Gin Stand

LC: Lint Cleaner

The experimental data and analysis of variance for each attribute are presented in the appendix.

TABLE II

SUMMARY OF LOT SIZE MEAN STATISTICS

Attribute	Means 250-lb. lots	Means 400-lb. lots	F Value	Probability of Difference Between Lot Size Means (Percent)	Half Width of 95 Percent Fiducial Interval
1. Gin Turnout (lbs. per bale unit)	568	570	0.55	$50 < P < 70$	4
2. Returns ($ per bale unit)	111	109	0.41	$P < 50$	4
3. Staple Length (in. x 32)	31.8	31.8	0.00	$P < 50$	0.2
4. Grade Index	71.7	70.9	0.75	$50 < P < 70$	1.4
5. Value of Lint (cents per pound)	19.5	19.2	0.75	$50 < P < 70$	0.6
6. Waste in Lint (percent)	5.10	5.01	0.51	$50 < P < 70$	0.21
7. Trash in Orig. Lot (percent)	22.3	21.4	4.44	$90 < P < 95$	0.7
8. Trash after ALC (percent)	18.6	18.3	0.56	$50 < P < 70$	0.5

TABLE II (Continued)

Attribute	Means: 250-lb. lots	Means: 400-lb. lots	F Value	Probability of Difference Between Lot Size Means (Percent)	Half Width of 95 Percent Fiducial Interval
9. Trash after BM (percent)	7.28	7.60	4.49	$90 < P < 95$	0.26
10. Trash after 7C (percent)	6.36	6.24	0.73	$50 < P < 70$	0.23
11. Trash after FDR (percent)	2.30	2.35	0.46	$P < 50$	0.11
12. Trash Removed by ALC (lbs. per bale unit)	41.3	41.6	0.05	$P < 50$	1.7
13. Trash Removed by BM (lbs. per bale unit)	360	357	1.30	$70 < P < 90$	4
14. Trash Removed by 7C (lbs. per bale unit)	12.6	11.8	0.78	$50 < P < 70$	1.6
15. Trash Removed by FDR (lbs. per bale unit)	75.2	75.0	0.36	$P < 50$	0.6
16. Trash Removed by HLF (lbs. per bale unit)	12.5	12.0	2.13	$70 < P < 90$	0.6
17. Trash Removed by GS (lbs. per bale unit)	4.72	4.88	3.07	$70 < P < 90$	0.15

TABLE II (Continued)

Attribute		Means		F Value	Probability of Difference Between Lot Size Means (Percent)	Half Width of 95 Percent Fiducial Interval
		250-lb. lots	400-lb. lots			
18.	Trash Removed by LC (lbs. per bale unit)	8.67	8.88	2.86	$70<P<90$	0.20
19.	Trash in Seed (percent)	1.44	1.48	0.03	$P<50$	0.36
20.	Moisture in Orig. Lot (percent)	9.58	9.40	1.82	$70<P<90$	0.22
21.	Moisture after FDR (percent)	8.80	8.96	1.28	$70<P<90$	0.23
22.	Moisture in Lint (percent)	8.61	8.45	1.52	$70<P<90$	0.22

TABLE III

SUMMARY OF LOT SIZE VARIABILITY STATISTICS

Attribute	Variance		F Value	Probability of Difference Between Lot Size Variances (Percent)	Standard Deviation		Coefficient of Variation (Percent)	
	250-lb. lots	400-lb. lots			250-lb. lots	400-lb. lots	250-lb. lots	400-lb. lots
1. Gin Turnout (lbs. per bale unit)	61	46	1.33	$50 < P < 70$	7.82	6.78	1.4	1.2
2. Returns ($ per bale unit)	92	46	1.99	$70 < P < 90$	9.62	6.82	8.7	6.3
3. Staple Length (in. x 32)	0.099	0.096	1.02	$50 < P < 70$	0.31	0.31	1.0	1.0
4. Grade Index	12.3	6.1	2.01	$70 < P < 90$	3.51	2.47	4.9	3.5
5. Value of Lint (cents per pound)	2.31	1.22	1.90	$70 < P < 90$	1.52	1.10	7.8	5.7
6. Waste in Lint (percent)	0.02	0.06	2.38	$70 < P < 90$	0.16	0.24	3.1	4.8
7. Trash in Orig. Lot (percent)	1.25	0.56	2.22	$70 < P < 90$	1.12	0.75	5.0	3.5
8. Trash after ALC (percent)	0.79	1.66	2.10	$70 < P < 90$	0.89	1.29	4.8	7.0

TABLE III (Continued)

Attribute	Variance 250-lb. lots	Variance 400-lb. lots	F Value	Probability of Difference Between Lot Size Variances (Percent)	Standard Deviation 250-lb. lots	Standard Deviation 400-lb. lots	Coefficient of Variation (Percent) 250-lb. lots	Coefficient of Variation (Percent) 400-lb. lots
9. Trash after BM (percent)	0.47	0.20	2.31	$70 < P < 90$	0.69	0.45	9.5	5.9
10. Trash after 7C (percent)	0.26	0.04	5.87	$95 < P < 99$	0.51	0.21	8.0	3.4
11. Trash after FDR (percent)	0.08	0.04	1.79	$70 < P < 90$	0.28	0.21	12.2	8.9
12. Trash Removed by ALC (lbs. per bale unit)	28.9	18.3	1.58	$70 < P < 90$	5.38	4.28	13.0	10.3
13. Trash Removed by BM (lbs. per bale unit)	907	175	5.18	$95 < P < 99$	30.1	13.2	8.4	3.7
14. Trash Removed by 7C (lbs. per bale unit)	6.13	2.58	2.37	$70 < P < 90$	2.47	1.61	19.6	13.6
15. Trash Removed by FDR (lbs. per bale unit)	5.07	1.48	3.43	$90 < P < 95$	2.25	1.22	3.0	1.6
16. Trash Removed by HLF (lbs. per bale unit)	1.15	0.19	6.05	$99 < P < 100$	1.07	0.44	8.6	3.7
17. Trash Removed by GS (lbs. per bale unit)	0.23	0.14	1.62	$70 < P < 90$	0.48	0.38	10.2	7.8

TABLE III (Continued)

Attribute	Variance 250-lb. lots	Variance 400-lb. lots	F Value	Probability of Difference Between Lot Size Variances (Percent)	Standard Deviation 250-lb. lots	Standard Deviation 400-lb. lots	Coefficient of Variation (Percent) 250-lb. lots	Coefficient of Variation (Percent) 400-lb. lots
18. Trash Removed by LC (lbs. per bale unit)	0.25	0.02	11.33	$99 < P < 100$	0.50	0.15	5.8	1.7
19. Trash in Seed (percent)	0.35	0.44	1.28	$50 < P < 70$	0.59	0.67	41.0	45.3
20. Moisture in Orig. Lot (percent)	0.31	0.21	1.44	$50 < P < 70$	0.55	0.46	5.7	4.9
21. Moisture after FDR (percent)	0.23	0.19	1.23	$50 < P < 70$	0.48	0.43	5.4	4.8
22. Moisture in Lint (percent)	0.06	0.09	1.48	$70 < P < 90$	0.24	0.30	2.8	3.5

CHAPTER VI

DISCUSSION OF RESULTS

Of the 22 attributes measured in this study, some are of considerably more importance than others in an ordinary ginning experiment. The principle criteria of evaluation in most ginning experiments include Gin Turnout, Returns, Staple Length, Grade Index, Value of Lint, and Waste in Lint. Other attributes may be of importance only in that they aid in explaining variations in the foregoing criteria. In some ginning experiments, however, the order of importance of some of the 22 attributes may be altered. For example, in a ginning experiment concerning the effect of varying degrees of drying in the gin, moisture determinations would be of major importance. Or in an experiment to evaluate the performance of some gin machine, the weight of trash removed by that and subsequent machines as well as the trash content of the cotton after certain machines would become more important criteria. Thus it is not possible to attach an inflexible order of importance to the attributes measured in this study. But since only one lot size can be used in any given experiment to determine all the attributes desired from that experiment, and if lot size appears to have an effect on certain attributes and not on others, some decision must be made as to which attributes might be sacrificed to the effects of a reduction in lot size and which attributes cannot tolerate those effects.

Since at least some of the 6 attributes enumerated in the preceding paragraph would be among the principle criteria of evaluation for any ginning experiment, those 6 attributes (items 1-6, tables II-IV) will be considered as being of critical importance. The effects of lot size on the accuracy and precision of determining those 6 attributes will therefore be of much greater concern than the effects of lot size on remaining attributes.

Another group of attributes which could be of major importance in an experiment to evaluate the performance of gin machines (hereafter designated as a type A experiment) are the measures of trash content of the seed cotton at various points in the gin (items 7-11, tables II-IV). Another group of attributes of somewhat less importance in a type A experiment include the quantitative measures of trash removed by each gin machine. These minor attributes are items 12 through 19 in tables II, III, and IV.

A fourth group of attributes (items 20-22, tables II-IV) could be of major importance in those experiments (type B) wherein moisture content determinations are among the principle criteria of evaluation.

The probability of a difference between the means estimated from the two lot sizes was between 50 and 70 percent for Gin Turnout, Grade Index, Value of Lint, and Waste in Lint, and was less than 50 percent for Returns and Staple Length (table II). This was rather weak evidence that lot size affected the accuracy of estimating the means of these critically important attributes. However, there was somewhat stronger evidence that some of these attributes were measured more precisely from 400-pound lots than from 250-pound lots. The probability of a greater variance associated with 250-pound lots was 70 to 90 percent for Returns, Grade Index, and Value of Lint (table III). Thus the precision of measuring these three attributes was probably lowered by a reduction in lot size even though such action may not have affected the accuracy of estimating their means.

Can this sacrifice of precision be tolerated?

The consequence of a loss in precision is a reduction in the probability of recognizing from the F test real differences among ginning treatment means. Or conversely, a loss of precision would necessitate greater differences among treatment means in order for these differences to be recognized as real rather than random. Thus the possibility of overlooking a substantial treatment effect would be increased when using a reduced lot size if a loss of precision accompanied the reduction in lot size. Since cotton ginners and growers are concerned particularly with the effects of ginning variates on Grade Index, Value of Lint, and Returns, it is believed that these attributes should be estimated from a ginning experiment with no less precision than can be obtained using 400-pound lots. The foregoing statement is not necessarily an endorsement of the precision obtainable with 400-pound lots.

The probability was between 50 and 70 percent that Gin Turnout was measured with less precision from 250-pound lots than from 400-pound lots. This was rather flimsy evidence that a reduction in lot size reduced the precision of measuring this attribute. For Waste in Lint, however, there was a 70 to 90 percent probability of an increase in precision associated with a reduction in lot size.

Of the 5 attributes of major importance in a type A ginning experiment, 3 were estimated from 250-pound lots with less than a 70 percent probability that the accuracy of estimation was affected by reducing the lot size. The probability of a loss in precision, however, was greater than 70 percent for 4 of these 5 attributes when lot size was reduced.

Of the 8 attributes of minor importance in a type A experiment, 4 were estimated from 250-pound lots with less than a 70 percent probability of some effect on the accuracy of estimation as a result of using the smaller lots. However, for 7 of these attributes there was greater than a 70 percent probability that they were measured less precisely from the smaller lots. One reason for the greater variability associated with small lots for these quantitative attributes is the conversion of original observations to bale unit values. This procedure has the disadvantage of distorting the variance associated with the original observations (9). When an observation is multiplied or divided by a constant, its variance is multiplied or divided by the square of that constant. Since the multiplier for 400-pound lots was approximately 5, while that for 250-pound lots was approximately 8, the variances of the original observations from 250-pound lots were multiplied by 64 while the variances of 400-pound lot observations were multipled by only 25. If the variances of the original observations from the two lot sizes were equal, the variance of the bale unit values for 250-pound lots could be expected to have an inherent magnitude of 64/25 or 2.56 times the magnitude of the variance for 400-pound lots. Then much of the greater variability associated with small lot quantitative observations was a mathematical consequence of bale unit conversion. But since it is the absolute magnitude of the variance which enters into the F test of differences among treatment means, the greater residual variance associated with small lots would reduce the probability of differences in ginning treatment means being found significant when small lots are used.

For the 3 attributes of major importance in a type B experiment, there was a 70 to 90 percent probability of some effect on the accuracy of estimating their means when lot size was reduced. For 2 of these attributes, the probability of a greater variance associated with the small lots was less than 70 percent. For the third attribute, however, there was a 70 to 90 percent probability of less variance when the small lots were used.

The effects of lot size on accuracy and precision are recapitulated in table IV. This table lists for each attribute the minimum lot size which would be permissible with respect to both accuracy and precision. The criteria on which to base the selection of a lot size for each attribute were as follows:

1. How great was the probability that the accuracy of the mean was affected by a reduction in lot size? It was arbitrarily decided that a probability of less than 70 percent was not a conclusive indication that lot size would affect accuracy. Then when the probability of a difference between lot size means was less than 70 percent, it would be permissible, although not mandatory, to use 250-pound lots. But the arbiter (the author) was not willing to risk the effect of lot size on accuracy at a probability greater than 70 percent. In this event, it was assumed that the lot size which most accurately estimates a population parameter is that size which most nearly approaches the population in size.[3] Therefore, 400-pound lots would be mandatory when the probability exceeded 70 percent.

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[3]This assumption was primarily intuitive. However, the end condition effects of the priming and de-priming periods, as discussed previously, would exert a disproportionately greater influence on certain attributes as lot size decreases. Therefore, by logical inference the end condition effects would disappear when the lot size became infinitely large; and the larger lots should therefore yield more accurate information about continuous ginning conditions than would smaller lots.

TABLE IV

SELECTION OF MINIMUM LOT SIZES

(SELECTIONS MADE WITH RESPECT TO EFFECTS OF LOT SIZE ON ACCURACY OF ESTIMATING MEANS AND PRECISION OF OBSERVATIONS)

Critical Attributes (All Experiments)	Accuracy Selection (Pounds)	Precision Selection (Pounds)	Integrated Selection (Pounds)
1. Gin Turnout	250	250	250
2. Returns	250	400	400
3. Staple Length	250	250	250
4. Grade Index	250	400	400
5. Value of Lint	250	400	400
6. Waste in Lint	250	250	250
Major Attributes (Type A Experiments)			
7. Trash in Orig. Lot	400	400	400
8. Trash after ALC	250	250	250
9. Trash after BM	400	400	400
10. Trash after 7C	250	400	400
11. Trash after FDR	250	400	400

TABLE IV (Continued)

Minor Attributes (Type A Experiments)	Accuracy Selection (Pounds)	Precision Selection (Pounds)	Integrated Selection (Pounds)
12. Trash Removed by ALC	250	400	400
13. Trash Removed by BM	400	400	400
14. Trash Removed by 7C	250	400	400
15. Trash Removed by FDR	250	400	400
16. Trash Removed by HLF	400	400	400
17. Trash Removed by GS	400	400	400
18. Trash Removed by LC	400	400	400
19. Trash in Seed	250	250	250
Major Attributes (Type B Experiments)			
20. Moisture in Original Lot	400	250	400
21. Moisture after FDR	400	250	400
22. Moisture in Lint	400	250	400

2. How great was the probability that a reduction in lot size would increase the variability of observations? Again it was decided not to risk the effect of lot size on the precision of estimating an attribute when the probability of a difference in variance between lot sizes was greater than 70 percent. In this event, the lot size having the least variance was selected. But when the probability of a difference in variance was less than 70 percent this was considered to be an acceptable risk of a difference in precision between lot sizes; therefore, 250-pound lots were considered permissible.

Since the two foregoing criteria frequently dictated the selection of one lot size from accuracy considerations, and another size from precision considerations, and since only one lot size can be used in an experiment, an integrated selection compatible with both accuracy and precision considerations was necessary for each attribute. This integrated selection is listed in the third column of table IV. As might be expected it is usually the larger of the two sizes selected for accuracy and precision individually, since the finally selected lot size must fulfill simultaneously the minimum criteria arbitrarily chosen for both accuracy and precision. For only one attribute was the integrated selection of lot size unable to satisfy the individual criteria of accuracy and precision. The probability of lot size having an effect on the accuracy of estimating this attribute (Moisture in Lint) was 70 to 90 percent. The criterion of accuracy therefore dictated the use of 400-pound lots. But at the same time, there was a 70 to 90 percent probability that 250-pound lots would yield more precise observations than would the 400-pound lots. The criterion of precision dictated the use of 250-pound lots. This incompatibility was resolved in favor of 400-pound lots since the other two attributes in that group required 400-pound lots.

From table IV, it appears that of the 6 attributes of critical importance in almost all ginning experiments, only Gin Turnout, Staple Length, and Waste in Lint should be determined from 250-pound lots. Returns, Grade Index, and Value of Lint would suffer a loss of precision when determined from 250-pound lots.

It is also noted from table IV that only 1 of the 5 attributes of major importance, and 1 of the 8 attributes of minor importance in a type A experiment should be determined from 250-pound lots. Also, none of the 3 attributes of major importance in a type B experiment should be determined from the smaller lots.

Then according to the criteria of selection, the use of 250-pound lots would be acceptable for only 5 of the 22 attributes; and these 5 attributes do not include 3 of those considered to be of critical importance. From this it can only be concluded that a serious loss of information from some important characteristics will result in any ginning experiment using 250-pound lots. And since such a few of the more important attributes can withstand the effects of a reduction in lot size, there appears to be no merit in further consideration of sacrificing some of the minor attributes to the effects of a reduced lot size.

Up to this point, the effects of lot size have been considered only under the assumption that the number of replications in the ginning experiment when using 250-pound lots would be the same as when using 400-pound lots. Perhaps an increase in replications of the small lots would sufficiently increase the precision of certain attributes while still resulting in a saving of experimental material over that required for

400-pound lots. It is noted from table IV that all of the 6 attributes of critical importance could be determined from 250-pound lots with respect to accuracy. This permits the consideration of an increase in replications to compensate for the loss of precision suffered by Returns, Grade Index, and Value of Lint when using 250-pound lots.

Formulas which have been derived for determining the number of replications necessary to obtain a prescribed degree of precision usually involve the variance as a measure of the desired precision. If it were desired to determine the number of replications of one lot size which would be required to obtain the precision of another lot size, it would be necessary only to compare the variances of the two lot sizes if they were available. The ratio of these two variances would also be the ratio of the replications required of each lot size to produce an equal degree of precision. Using the variances of Returns as an example (table III), 92/46 or 2 times as many replications of 250-pound lots would be required to yield the degree of precision which could be obtained with 400-pound lots.

The total amount of cotton necessary for a ginning experiment is a function of the number of lots and of lot size. The number of lots necessary in the experiment is in turn a function of the number of replications. Then when comparing the total amount of cotton required when using 250-pound lots with the amount required when using 400-pound lots, it would be necessary only to multiply the ratio of the 2 lot sizes by the number of replications required of 250-pound lots to yield the precision of 400-pound lots. For example, it was found that twice as many replications of 250-pound lots would be required to yield the precision of 400-pound lots for Returns. Then the total amount of cotton necessary when using 250-pound lots would be (2)(250/400) or 1.25 times the amount necessary when using 400-pound lots. Thus more cotton would be required when using the smaller lots than when using the larger lots if the precision of the larger were to be maintained. Similarly, it was found for Grade Index and Value of Lint that a 25 percent increase in the total amount of cotton would be required if 250-pound lots were used.

An increase in replications would be necessary when the ratio of variances between small and large lots exceeded unity; but a saving of cotton would still be possible if this ratio was less than 400/250 or 1.6. When this analysis was applied to the 5 remaining attributes (items 10, 11, 12, 14, and 15, table IV) for which 250-pound lots were selected as acceptable with respect to accuracy, but for which 400-pound lots were selected for precision, a saving of cotton could be shown for only 1 attribute (item 12). And this required an increase in the number of replications of 250-pound lots to prevent a loss of precision.

But if a reduction in lot size reduces the total amount of cotton required while at the same time increases the number of replications and therefore the number of lots required, has a net reduction in the cost of the experiment been realized? The cost of conducting a ginning experiment is a function of the total number of lots in the experiment and of the total amount of cotton used. The cost factor which is a function of the number of lots is independent of lot size in that certain tasks must be performed for each lot ginned, regardless of size. The cost factor which is a function of the total amount of cotton in the experiment would be affected by lot size in that less labor and power would be required for each lot if its size were reduced.

It is estimated that the fixed cost of processing a test lot is 50 dollars, and that the variable cost of processing each lot is 0.5 cents per pound excluding the cost of the cotton. Then the cost of a typical ginning experiment having 7 replications of 4 treatments with 400-pound lots would be $(50)(7)(4) + (.005)(7)(4)(400) = 1400 + 56 = 1456$ dollars. It was found that the precision of measuring Trash after Air-Line Cleaner (item 12, tables II-IV) could be maintained with 250-pound lots if 11 replications were used. The cost of the 4-treatment ginning experiment would then be $(50)(11)(4) + (.005)(11)(4)(250) = 2200 + 55 = 2255$ dollars. Thus it is seen that a 200-pound reduction in the total amount of cotton required for an experiment by the proposed reduction in lot size would result in a considerably more expensive experiment. The reason for this is the low variable cost factor associated with lot size; it costs very little more to process a 400-pound lot than to process a 250-pound lot. If the cost of the cotton were included in the variable cost factor, a reduction in lot size could more nearly be justified on an economic basis; but the inclusion of cotton cost is not logical since the lint and seed obtained as a by-product of the experiment off-set the cost of the cotton used.

From the foregoing cost analysis, it appears that increasing the number of replications of 250-pound lots to maintain the precision of 400-pound lots would usually be an expensive method of conserving cotton. And even so, because of the excessive number of replications required, a conservation of cotton would be possible for only 1 of the 8 attributes not already limited to determination from 400-pound lots as a result of accuracy considerations, and for which an integrated selection of 250-pound lots had not already been made. The 5 attributes (items

1, 3, 6, 8, and 19, tables II-IV) which could be measured with no substantial indication of a loss of accuracy or precision from 250-pound lots, and therefore without an increase in the number of replications, would seldom if ever constitute the principle criteria of evaluating a ginning experiment. Therefore it appears that a reduction in lot size, either with or without an increase in replications, would seldom be feasible.

Other information incidental to this study is apparent from the coefficients of variation in table III. For example, it appears that Trash in Seed was measured with little precision from either 250 or 400-pound lots. Fortunately, this is one of the least important attributes measured in a ginning experiment. It also appears that Trash Removed by Air-Line Cleaner and 7-Cylinder Cleaner were measured with rather low precision. With one exception, Gin Turnout was the most precise measurement made considering the magnitude of the mean of this attribute. Staple Length was the most precisely measured of all attributes. This is indeed surprising in view of the fact that Staple Length is visually estimated by the cotton classer and no physical measurements of the fiber are made. Grade Index, another attribute determined by visual inspection in the cotton classing office, was also measured with relatively high precision.

CHAPTER VII

SUMMARY AND CONCLUSIONS

An investigation was made of the effects of a reduction in experimental unit or lot size on the reliability of cotton ginning research data. A ginning experiment was conducted wherein the only variate was lot size; these sizes were 250 and 400 pounds. The reduction in lot size was evaluated by its effect on 22 attributes normally measured in a ginning experiment. The criteria of evaluation were the effects of lot size on the accuracy of estimating each attribute mean, and on the precision of observations which established each mean.

No substantial evidence was found that the reduction in lot size affected the accuracy with which the critically important attribute means were estimated. There was considerable probability, however, that 3 of the 6 critically important attribute means were measured with less precision from 250-pound lots than from 400-pound lots. Any loss of precision was believed unacceptable for these 3 attributes.

Of 8 attributes which could be of major importance in certain types of ginning experiments, there was considerable probability that a reduction in lot size had some effect on the accuracy of estimating 5 of their means, and reduced the precision with which 4 of them could be measured.

Of 8 attributes which would be of minor importance in many experiments, there was considerable probability that the accuracy of estimating the means of 4 of them was affected by a reduction in lot size, and that the precision of estimating 7 of their means was reduced by the reduction in lot size.

For each of the 22 attributes, a decision was made as to which of the two lot sizes should be used for measuring those attributes. The criteria of decision were based on the levels of probability that the reduction in lot size affected the accuracy or lowered the precision with which each attribute mean was estimated. At a probability level below 70 percent, 250-pound lots were found suitable for only 5 of the attributes. These were as follows:

1. Gin Turnout
2. Staple Length
3. Waste in Lint
4. Trash after Air-Line Cleaner
5. Trash in Seed

A saving of cotton could be realized for one other attribute by reducing the lot size and increasing the number of replications to offset the accompanying loss of precision. For other attributes, the necessary increase in replications was so great that no saving of cotton would result. But even for that attribute for which a saving of cotton could be realized by a limited increase in replications, the expense of processing the additional replications would greatly increase the cost of the experiment.

For the few attributes for which a reduction in lot size did not necessitate an increase in replications to maintain the precision of a larger lot size, a saving of cotton could be realized with a slight reduction in the cost of the experiment.

The following conclusions were drawn from the results of this investigation:

1. Reducing the ginning lot size from 400 to 250 pounds entails at least a 70 percent probability of some effect on the accuracy of estimating 9 of the 22 attribute means normally measured in a ginning experiment.

2. The probability of a loss of precision as a result of the reduction in lot size is at least 70 percent for 14 of the 22 attributes studied.

3. The 5 attributes which can be determined from 250-pound lots with no substantial indication of a loss of precision or accuracy, and without an increase in replications, do not include several of the more important attributes by which many ginning experiments are evaluated.

4. For only one additional attribute can a saving of cotton be realized by a reduction in lot size and increase in replications to offset the accompanying loss of precision; and the added cost of processing the added replications makes this saving of cotton extremely expensive.

5. The loss of precision and possible loss of accuracy in measuring some of the more important attributes will discourage the use of 250-pound lots except in those rare experiments where the principle criteria of evaluation are those few attributes not adversely affected by a reduction in lot size.

6. If 250 rather than 400-pound lots are used in a ginning experiment, the resulting loss of precision in measuring certain important attributes would lower the significance of differences among ginning treatment means. Therefore the use of 250-pound lots would frequently result in erroneous acceptance of the null

hypothesis; thus many important effects of a ginning treatment might not be recognized when 250-pound lots are used.

7. In the event that sufficient cotton is not available for the use of 400-pound lots in an experiment, it should probably be conducted with a reduced lot size since even a limited amount of information from a ginning experiment would usually be more desirable than none at all. But in this event, extra caution should be employed when interpreting the results of the experiment since the interpretational assistance offered by statistical analysis would be somewhat curtailed.

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APPENDIX

DATA AND ANALYSIS SHEET I

GIN TURNOUT
(POUNDS PER BALE UNIT)

Replication	250-pound lots		400-pound lots	
1	544	565	569	560
2	568	558	559	575
3	576	567	572	581
4	574	569	572	572
5	572	576	574	565
6	561	578	578	564
7	565	564	573	568
8	573	578	568	564

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	1759			
Replication	7	612			
Lot Size	1	21	21.00	.546	$50<P<70$
Rep. x Size	7	269	38.43		
Sampling Error	16	857			
Within Small Lots	8	489	61.12	1.33	$50<P<70$
Within Large Lots	8	368	46.00		

DATA AND ANALYSIS SHEET II

RETURNS
(DOLLARS PER BALE UNIT)

Replication	250-pound lots		400-pound lots	
1	97	125	101	100
2	102	101	101	110
3	114	101	102	123
4	110	115	103	113
5	122	115	110	120
6	107	121	115	111
7	112	112	120	119
8	118	102	102	100

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	2120			
Replication	7	686			
Lot Size	1	18	18.0	0.41	P<50
Rep. x Size	7	304	43.4		
Sampling Error	16	1112			
Within Small Lots	8	740	92.5	1.99	70<P<90
Within Large Lots	8	372	46.5		

DATA AND ANALYSIS SHEET III

STAPLE LENGTH (IN X 32)

Replication	250-pound lots		400-pound lots	
1	31.33	32.00	31.33	31.33
2	32.33	32.33	32.00	32.66
3	31.66	31.66	31.66	32.00
4	33.00	32.66	32.33	32.33
5	32.33	31.66	32.33	32.00
6	32.00	31.33	31.66	31.00
7	31.33	31.33	31.33	31.33
8	30.66	31.00	32.00	31.33

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	9.5061			
Replication	7	6.7153			
Lot Size	1	0.0001	0.0001	0.00	$P < 50$
Rep. x Size	7	1.2294	0.1756		
Sampling Error	16	1.5613			
Within Small Lots	8	0.7890	0.0986	1.02	$50 < P < 70$
Within Large Lots	8	0.7723	0.0965		

DATA AND ANALYSIS SHEET IV

GRADE INDEX

Replication	250-pound lots		400-pound lots	
1	68.00	77.66	68.00	68.00
2	68.00	68.00	68.00	70.33
3	72.66	68.00	68.00	75.00
4	70.33	72.66	68.00	72.66
5	75.00	72.66	70.33	75.00
6	70.33	75.00	72.66	72.66
7	72.66	72.66	75.00	75.00
8	75.00	68.00	68.00	68.00

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	285.5164			
Replication	7	91.6723			
Lot Size	1	4.4850	4.4850	.747	$50 < P < 70$
Rep. x Size	7	42.0101	6.0014		
Sampling Error	16	147.3490			
Within Small Lots	8	98.3723	12.2965	2.01	$70 < P < 90$
Within Large Lots	8	48.9767	6.1221		

DATA AND ANALYSIS SHEET V

VALUE OF LINT
(CENTS PER POUND)

Replication	250-pound lots		400-pound lots	
1	17.81	22.09	17.81	17.81
2	18.04	18.04	18.01	19.19
3	19.87	17.91	17.91	21.14
4	19.22	20.31	18.04	19.81
5	21.29	19.99	19.11	21.21
6	19.07	20.91	19.99	19.74
7	19.89	19.89	20.91	20.91
8	20.62	17.69	18.01	71.81

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	55.0913			
Replication	7	18.0132			
Lot Size	1	0.8547	0.8547	.749	$50<P<70$
Rep. x Size	7	7.9837	1.1405		
Sampling Error	16	28.2397			
Within Small Lots	8	18.5043	2.3130	1.90	$70<P<90$
Within Large Lots	8	9.7354	1.2169		

DATA AND ANALYSIS SHEET VI

WASTE IN LINT
(PERCENT)

Replication	250-pound lots		400-pound lots	
1	6.01	5.80	5.98	5.52
2	6.36	6.43	5.87	5.85
3	4.35	4.74	4.78	5.45
4	4.73	4.78	4.95	4.93
5	4.82	4.87	4.67	4.68
6	4.83	5.15	4.45	4.62
7	4.70	4.73	5.02	4.55
8	4.53	4.81	4.48	4.39

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	11.0541			
Replication	7	9.4351			
Lot Size	1	0.0657	0.0657	.511	$50 < P < 70$
Rep. x Size	7	0.8997	0.1285		
Sampling Error	16	0.6536			
Within Small Lots	8	0.1939	0.0242		
Within Large Lots	8	0.4597	0.0575	2.38	$70 < P < 90$

DATA AND ANALYSIS SHEET VII

TRASH IN ORIGINAL LOT (PERCENT)

Replication	250-pound lots		400-pound lots	
1	22.25	21.46	20.39	21.23
2	22.78	24.13	21.24	22.11
3	23.45	23.11	21.18	22.25
4	23.55	21.02	20.76	20.66
5	23.46	20.55	21.26	23.30
6	21.35	21.65	22.19	22.28
7	22.04	20.88	22.40	21.16
8	23.51	22.42	20.51	19.68

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	38.9026			
Replication	7	6.2229			
Lot Size	1	7.0406	7.0406	4.44	$90<P<95$
Rep. x Size	7	11.1048	1.5864		
Sampling Error	16	14.5343			
Within Small Lots	8	10.0275	1.2534	2.22	$70<P<90$
Within Large Lots	8	4.5068	0.5633		

DATA AND ANALYSIS SHEET VIII

TRASH AFTER AIR-LINE CLEANER
(PERCENT)

Replication	250-pound lots		400-pound lots	
1	19.82	16.64	18.56	18.40
2	18.71	19.06	18.88	17.83
3	18.48	19.16	19.94	16.46
4	19.62	19.24	18.45	18.88
5	18.58	17.69	19.13	18.08
6	17.62	18.49	17.23	19.28
7	19.46	19.16	18.50	16.49
8	18.08	17.62	19.79	17.82

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	27.4703			
Replication	7	2.0193			
Lot Size	1	0.4301	0.4301	.563	$50 < P < 70$
Rep. x Size	7	5.3500	0.7643		
Sampling Error	16	19.6709			
Within Small Lots	8	6.3462	0.7933		
Within Large Lots	8	13.3247	1.6656	2.10	$70 < P < 90$

DATA AND ANALYSIS SHEET IX

TRASH AFTER BURR MACHINE
(PERCENT)

Replication	250-pound lots		400-pound lots	
1	7.55	6.45	7.74	8.27
2	7.76	8.62	7.53	8.35
3	7.94	7.49	7.88	7.28
4	6.68	8.05	8.18	8.15
5	7.08	7.06	6.92	7.73
6	7.35	6.68	6.60	7.66
7	7.52	6.68	7.59	7.60
8	5.99	7.53	7.27	6.86

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	11.6514			
Replication	7	4.0955			
Lot Size	1	0.8386	0.8386	4.49	$90 < P < 95$
Rep. x Size	7	1.3085	0.1869		
Sampling Error	16	5.4089			
Within Small Lots	8	3.7778	0.4722	2.31	$70 < P < 90$
Within Large Lots	8	1.6311	0.2039		

DATA AND ANALYSIS SHEET X

TRASH AFTER 7-CYLINDER INCLINED SCREEN CLEANER (PERCENT)

Replication	250-pound lots		400-pound lots	
1	6.74	6.26	6.49	6.30
2	7.03	7.51	6.48	6.15
3	6.03	6.88	6.21	6.46
4	5.86	6.92	6.58	6.00
5	6.46	5.91	5.97	6.21
6	6.42	5.30	6.42	6.18
7	6.21	6.02	5.86	6.08
8	5.88	6.42	6.24	6.32

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	5.3326			
Replication	7	1.6919			
Lot Size	1	0.1129	0.1129	.735	$50<P<70$
Rep. x Size	7	1.0751	0.1536		
Sampling Error	16	2.4528			
Within Small Lots	8	2.0958	0.2620	5.87	$95<P<99$
Within Large Lots	8	0.3570	0.0446		

DATA AND ANALYSIS SHEET XI

TRASH AFTER EXTRACTOR-CLEANER-FEEDER
(PERCENT)

Replication	250-pound lots		400-pound lots	
1	2.66	1.89	2.30	2.66
2	2.56	3.01	2.75	2.61
3	2.01	2.30	2.16	2.40
4	2.30	2.32	2.67	2.60
5	2.05	2.05	2.28	2.00
6	2.05	2.46	2.37	2.19
7	2.24	2.47	1.92	2.17
8	2.08	2.47	2.01	2.57

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	2.3572			
Replication	7	1.1020			
Lot Size	1	0.0171	0.0171	.456	$P < 50$
Rep. x Size	7	0.2623	0.0375		
Sampling Error	16	0.9758			
Within Small Lots	8	0.6265	0.0783	1.79	$70 < P < 90$
Within Large Lots	8	0.3493	0.0437		

DATA AND ANALYSIS SHEET XII

TRASH REMOVED BY AIR-LINE CLEANER
(POUNDS PER BALE UNIT)

Replication	250-pound lots		400-pound lots	
1	34.7	42.9	34.0	35.2
2	32.8	40.7	35.7	42.9
3	43.8	37.2	37.8	46.3
4	44.7	40.6	40.3	38.3
5	47.6	43.0	41.3	48.2
6	50.0	40.4	43.0	52.3
7	42.9	42.6	40.0	45.4
8	45.0	32.4	41.9	42.4

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	732.62			
Replication	7	299.03			
Lot Size	1	0.43	0.43	.054	P<50
Rep. x Size	7	55.54	7.93		
Sampling Error	16	377.62			
Within Small Lots	8	231.10	28.89	1.58	70<P<90
Within Large Lots	8	146.52	18.31		

DATA AND ANALYSIS SHEET XIII

TRASH REMOVED BY BURR MACHINE
(POUNDS PER BALE UNIT)

Replication	250-pound lots		400-pound lots	
1	424	315	356	385
2	377	375	386	358
3	347	391	366	337
4	358	356	357	354
5	347	346	339	343
6	358	338	344	357
7	370	354	354	359
8	353	358	368	357

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	11829			
Replication	7	2731			
Lot Size	1	69	69	1.30	$70<P<90$
Rep. x Size	7	372	53		
Sampling Error	16	8657			
Within Small Lots	8	7254	907	5.18	$95<P<99$
Within Large Lots	8	1403	175		

DATA AND ANALYSIS SHEET XIV

TRASH REMOVED BY 7-CYLINDER INCLINED SCREEN CLEANER (POUNDS PER BALE UNIT)

Replication	250-pound lots		400-pound lots	
1	14.6	13.7	9.4	10.2
2	10.2	15.4	9.4	11.0
3	13.5	10.2	11.5	12.5
4	17.2	12.0	10.5	10.3
5	12.8	10.1	10.0	13.0
6	12.0	10.4	14.1	15.0
7	9.5	13.0	14.6	11.5
8	12.1	15.3	10.5	14.7

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	139.10			
Replication	7	10.37			
Lot Size	1	5.95	5.95	.785	50<P<70
Rep. x Size	7	53.07	7.58		
Sampling Error	16	69.71			
Within Small Lots	8	49.06	6.13	2.37	70<P<90
Within Large Lots	8	20.65	2.58		

DATA AND ANALYSIS SHEET XV

TRASH REMOVED BY EXTRACTOR-CLEANER-FEEDER (POUNDS PER BALE UNIT)

Replication	250-pound lots		400-pound lots	
1	74.5	70.3	73.3	72.7
2	73.8	78.9	74.1	75.3
3	79.1	74.7	74.1	76.6
4	75.0	75.6	76.9	74.9
5	75.3	74.3	72.6	75.1
6	77.2	73.7	74.5	76.8
7	74.1	74.8	75.6	75.3
8	77.0	75.0	75.9	76.1

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	95.71			
Replication	7	35.51			
Lot Size	1	0.38	0.38	.358	$P<50$
Rep. x Size	7	7.40	1.06		
Sampling Error	16	52.42			
Within Small Lots	8	40.56	5.07	3.43	$90<P<95$
Within Large Lots	8	11.86	1.48		

DATA AND ANALYSIS SHEET XVI

TRASH REMOVED BY GIN STAND HULLER FRONT (POUNDS PER BALE UNIT)

Replication	250-pound lots		400-pound lots	
1	13.7	1.11	12.0	12.3
2	14.4	12.9	13.0	13.2
3	13.5	16.1	12.6	12.5
4	12.1	12.9	12.1	11.9
5	12.8	11.8	10.0	11.5
6	11.1	10.4	11.5	10.9
7	11.2	11.3	12.0	11.5
8	12.1	12.8	12.6	12.6

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	43.62			
Replication	7	24.34			
Lot Size	1	2.00	2.00	2.13	$70 < P < 90$
Rep. x Size	7	6.56	0.94		
Sampling Error	16	10.72			
Within Small Lots	8	9.20	1.15	6.05	$99 < P < 100$
Within Large Lots	8	1.52	0.19		

DATA AND ANALYSIS SHEET XVII

TRASH REMOVED BY GIN STAND
(POUND PER BALE UNIT)

Replication	250-pound lots		400-pound lots	
1	4.97	3.77	3.98	5.12
2	5.17	4.29	5.33	5.32
3	5.22	5.26	5.25	5.36
4	5.26	4.98	4.90	4.75
5	4.79	4.47	4.42	4.90
6	5.14	3.99	4.58	4.82
7	4.48	4.61	4.69	5.18
8	4.50	4.60	5.08	4.41

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	5.7129			
Replication	7	1.9972			
Lot Size	1	0.2096	0.2096	3.07	$70 < P < 90$
Rep. x Size	7	0.4773	0.0682		
Sampling Error	16	3.0288			
Within Small Lots	8	1.8731	0.2341	1.62	$70 < P < 90$
Within Large Lots	8	1.1557	0.1445		

DATA AND ANALYSIS SHEET XVIII

TRASH REMOVED BY LINT CLEANER (POUNDS PER BALE UNIT)

Replication	250-pound lots		400-pound lots	
1	8.56	6.86	8.37	8.70
2	9.32	8.58	9.40	9.48
3	9.26	9.34	9.46	9.37
4	8.62	8.59	8.95	8.79
5	8.56	8.44	8.42	8.87
6	8.58	8.67	8.86	8.82
7	8.61	8.70	8.34	8.37
8	8.65	9.38	8.90	8.92

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	7.7287			
Replication	7	4.3748			
Lot Size	1	0.3403	0.3403	2.86	70<P<90
Rep. x Size	7	0.8322	0.1189		
Sampling Error	16	2.1814			
Within Small Lots	8	2.0042	0.2505	11.33	99<P<100
Within Large Lots	8	0.1772	0.0221		

DATA AND ANALYSIS SHEET XIX

TRASH IN SEED (PERCENT)

Replication	250-pound lots		400-pound lots	
1	1.11	1.55	1.00	0.67
2	1.33	2.00	1.67	1.33
3	2.00	1.22	1.11	1.00
4	1.67	1.44	1.44	1.55
5	0.67	1.33	3.44	1.33
6	0.78	1.67	1.44	1.67
7	0.78	1.55	0.78	1.55
8	1.22	2.78	1.22	2.55

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	11.1876			
Replication	7	2.2266			
Lot Size	1	0.0132	0.0132	.035	$P<50$
Rep. x Size	7	2.6110	0.3730		
Sampling Error	16	6.3368			
Within Small Lots	8	2.7790	0.3474		
Within Large Lots	8	3.5578	0.4447	1.28	$50<P<70$

DATA AND ANALYSIS SHEET XX

MOISTURE IN ORIGINAL LOT
(PERCENT)

Replication	250-pound lots		400-pound lots	
1	9.38	8.64	8.78	9.40
2	9.84	9.14	9.78	9.50
3	10.30	9.44	9.56	8.94
4	9.82	8.82	9.30	8.68
5	9.62	8.94	9.04	10.38
6	10.66	9.64	9.54	9.98
7	10.24	9.66	9.14	9.54
8	9.86	9.32	9.38	9.50

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	7.6342			
Replication	7	2.2288			
Lot Size	1	0.2592	0.2592	1.82	70<P<90
Rep. x Size	7	0.9946	0.1421		
Sampling Error	16	4.1516			
Within Small Lots	8	2.4540	0.3067	1.44	50<P<70
Within Large Lots	8	1.6976	0.2122		

DATA AND ANALYSIS SHEET XXI

MOISTURE AFTER EXTRACTOR-CLEANER-FEEDER (PERCENT)

Replication	250-pound lots		400-pound lots	
1	8.48	8.94	9.74	9.06
2	8.94	9.48	8.26	9.46
3	8.32	8.40	8.38	8.98
4	8.00	9.56	8.76	8.60
5	8.36	8.68	9.08	8.68
6	8.82	8.84	8.96	8.52
7	8.90	9.24	9.96	9.44
8	8.58	9.32	8.60	8.90

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	6.6574			
Replication	7	2.0162			
Lot Size	1	0.1984	0.1984	1.28	$70 < P < 90$
Rep. x Size	7	1.0872	0.1553		
Sampling Error	16	3.3556			
Within Small Lots	8	1.8546	0.2318	1.23	$50 < P < 70$
Within Large Lots	8	1.5010	0.1876		

DATA AND ANALYSIS SHEET XXII

MOISTURE IN LINT
(PERCENT)

Replication	250-pound lots		400-pound lots	
1	8.55	8.45	8.45	8.30
2	9.40	9.25	7.80	8.75
3	8.70	8.75	8.60	8.70
4	8.75	8.90	8.70	9.00
5	8.10	8.35	8.30	8.25
6	8.10	8.20	8.20	8.15
7	8.50	8.40	8.25	8.60
8	9.15	8.25	8.85	8.35

ANALYSIS OF VARIANCE

Source of Variation	df	ss	ms	F	P
Total	31	4.0631			
Replication	7	1.7487			
Lot Size	1	0.2033	0.2033	1.52	70<P<90
Rep. x Size	7	0.9348	0.1335		
Sampling Error	16	1.1763			
Within Small Lots	8	0.4750	0.0594		
Within Large Lots	8	0.7013	0.0877	1.48	70<P<90

VITA

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Master of Science

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